Battelle
The Business of Innovation

# The ENVVEST Approach to Stormwater Pollutant Loading in the Sinclair- Dyes Inlet Watershed

Jill Brandenberger, Chris May, Eric Crecelius, Martin Miller
Battelle MSL, Sequim, WA, USA

Robert K. Johnston
Space and Naval Warfare Systems Center, San Diego, CA, USA

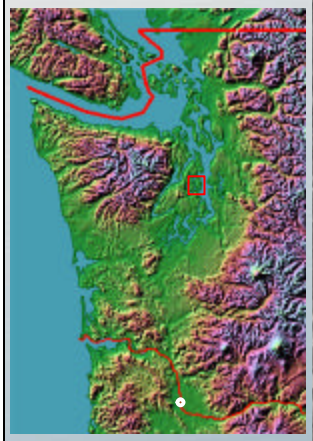
Jerry Sherrell
Puget Sound Naval Shipyard, Bremerton, WA, USA

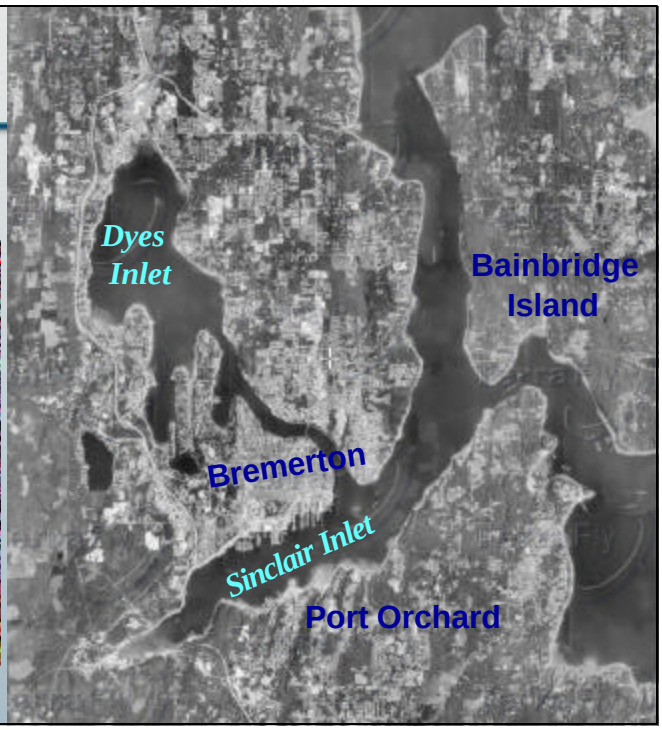


## Presentation Outline

- Project ENVVEST
- Draft Sediment Mass Balance
- Data Gaps – Stormwater Loading
- Stormwater Collection and Analysis in 2003/2004
- Storm Event Means and Discrete Sampling during Storm Events
- Correlations with LULC
- Conclusions

## Study Area

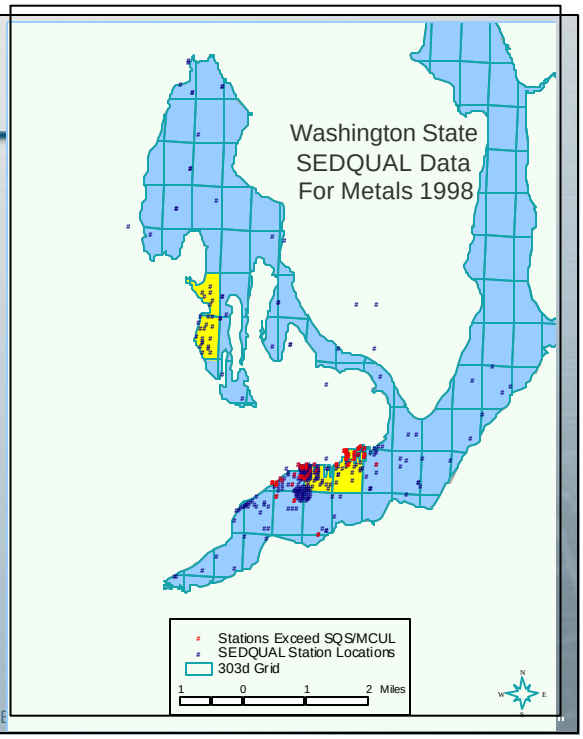





## 1998 3O3(d) Listings for Sediment

**Sinclair Inlet:** As, Cu, Pb, Zn, Cd, Hg, PCBs, Phalates,and PAHs

**Dyes Inlet:** Cd, Ag, Hg, Phenol, Toxicity



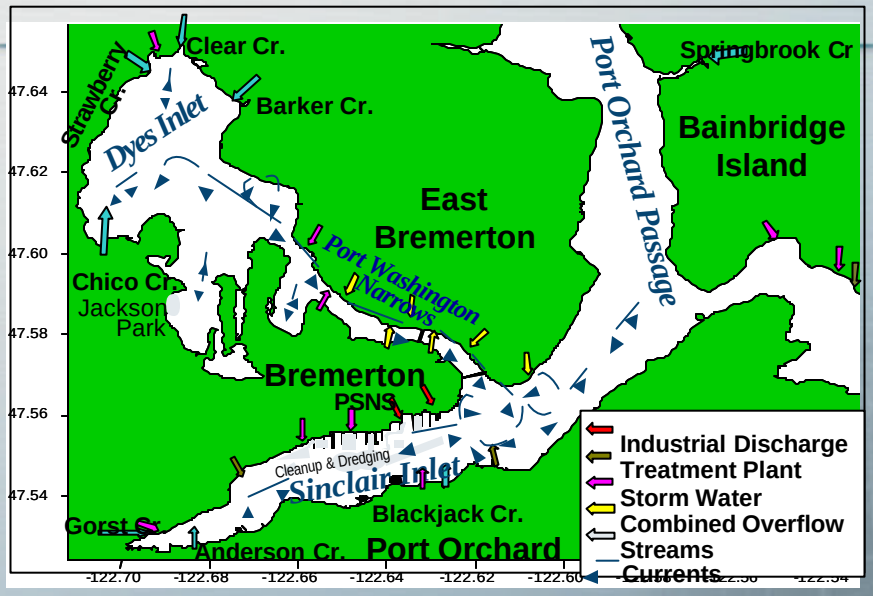
# Puget Sound Naval Shipyard Project ENVVEST–A Cooperative Agreement

- US-EPA Region 10
- Suquamish Tribe
- Puget Sound Naval Shipyard & Intermediate Maintenance Activity
- Washington State
  - Department of Ecology
  - Department of Health
  - Department of Transportation
- Kitsap County
  - Kitsap County Health District
  - Surface and Stormwater Management
  - Kitsap County Conservation District
- City of Bremerton
- City of Port Orchard
- City of Bainbridge Island



Battelle

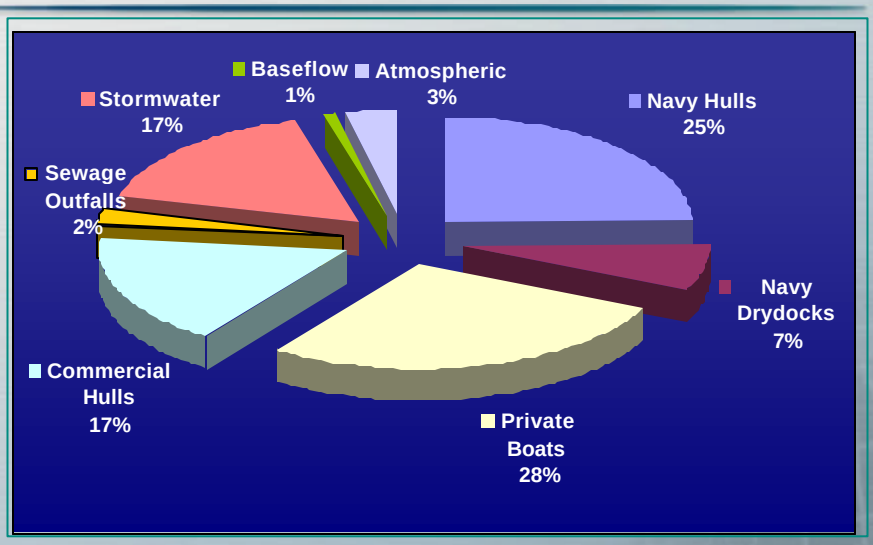
## Conceptual Model






Battelle

# Draft Mass Balance Cu Sources




Crecelius, E.A. et al., 2003. Contaminant Mass Balance for Sinclair and Dyes Inlets, Puget Sound.



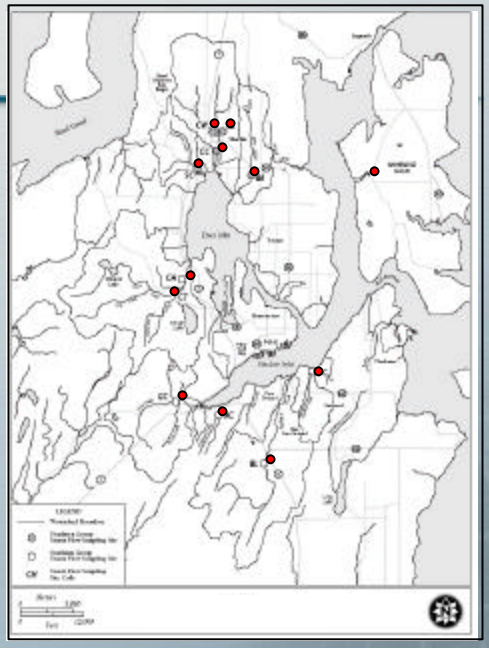
# Draft Mass Balance Conclusions

- Sediment Quality is improving slowly
- Low sedimentation rate,
  < 0.5 cm/year
- Copper budget uncertainty
  - Tidal exchange budget
  - Loading from hulls and storm events
  - Refining sediment budget

## Stream Sampling

- Sinclair Inlet:
  - Olney Creek
  - Blackjack Creek
  - Anderson Creek
  - Gorst Creek
- Dyes Inlet:
  - Clear Creek East
  - Clear Creek West
  - Clear Creek Main Stem
  - Strawberry Creek
  - Barker Creek

Collected 7 Storms in Spring 2003/2004



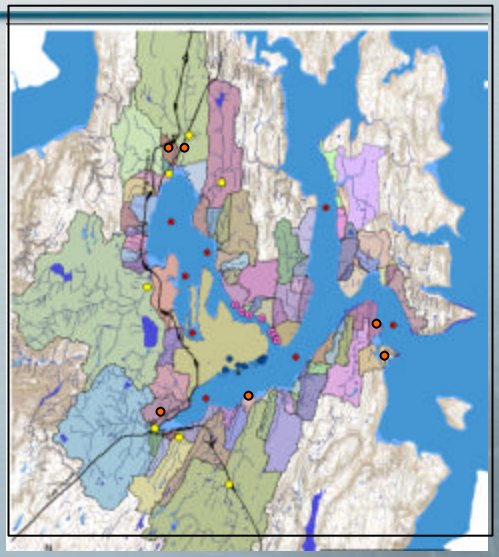




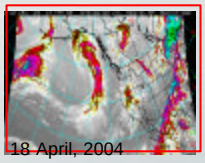
## Marine and Stormwater Outfalls

- PSNS Team
- City of Bremerton Outfalls
- Kitsap County Outfalls
- Bainbridge Island
- Marine Team
- WWTP Team

Collected 3 Storms in Spring 2004



## Methods: Storm Event Monitoring







- Qualifying storms classified as precipitation > 0.25 inches in a 24 hour period following a discernable dry period.
- Automatic samplers initiate collection when precipitation >0.05 inches in 1 hour for a qualifying storm. Flow is recorded at 15 minute intervals using area/velocity meters.
- Samples collected at the following intervals:
  - Streams ⇨ 140 ml / 15 minutes for 6 hours per discrete sample
  - Storm Drains ⇨ 95 ml / 5 minutes for 3 hour per discrete sample



## Compositing and Analysis

**Composites:**

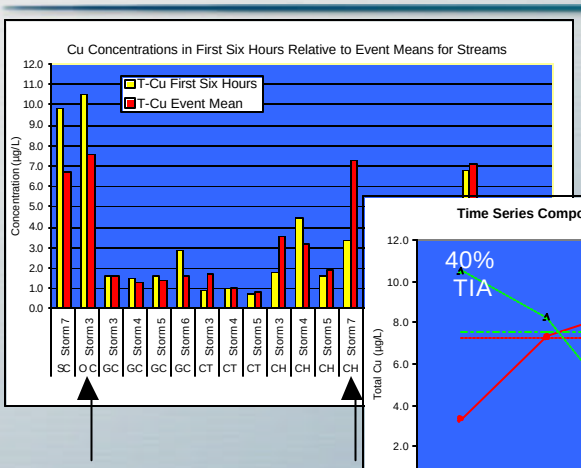
**Storm Drains = Flow Weighted**

**Streams = Equal Portion**


**Selected discrete samples and storm event mean composites were analyzed for:**

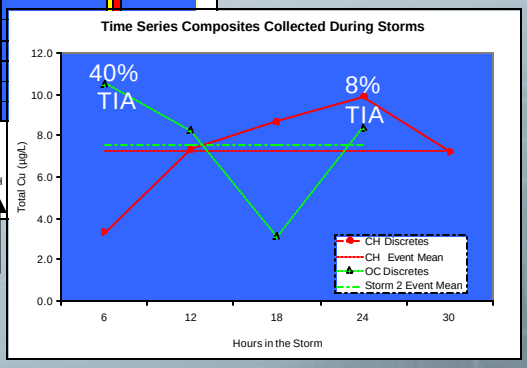
- ✓Al, Ag, As, Cd, Cu, Cr, Pb, Zn, Hg
- ✓PAHs and PCBs
- ✓TOC, DOC, nutrients, TSS/TS, alkalinity, and hardness.

# First Flush in Streams




First Flush Correlation with Event Mean Concentration

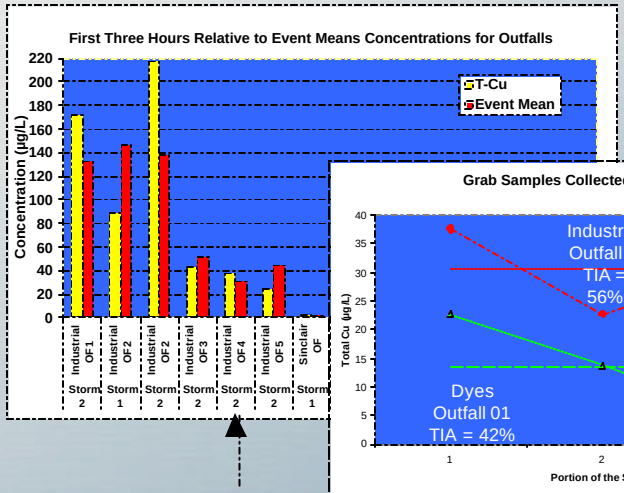
$R^2$= 0.717





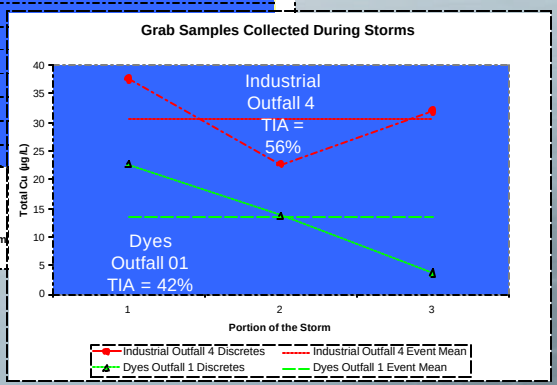

Battelle

# First Flush for Storm Drains




First Flush Correlation with Event Mean Concentration

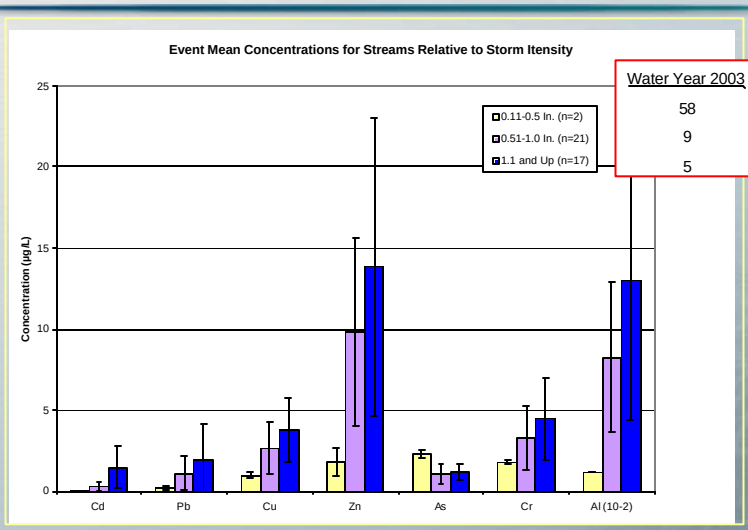
$R^2$= 0.818






Battelle

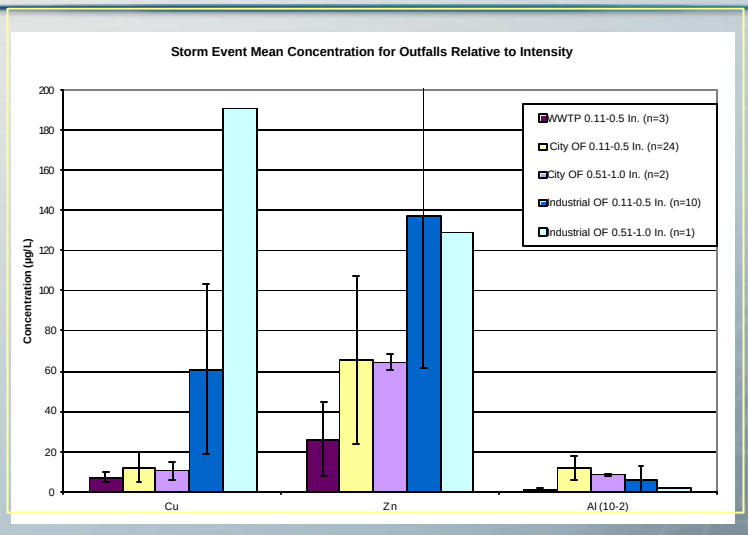
# Relationship with Storm Intensity



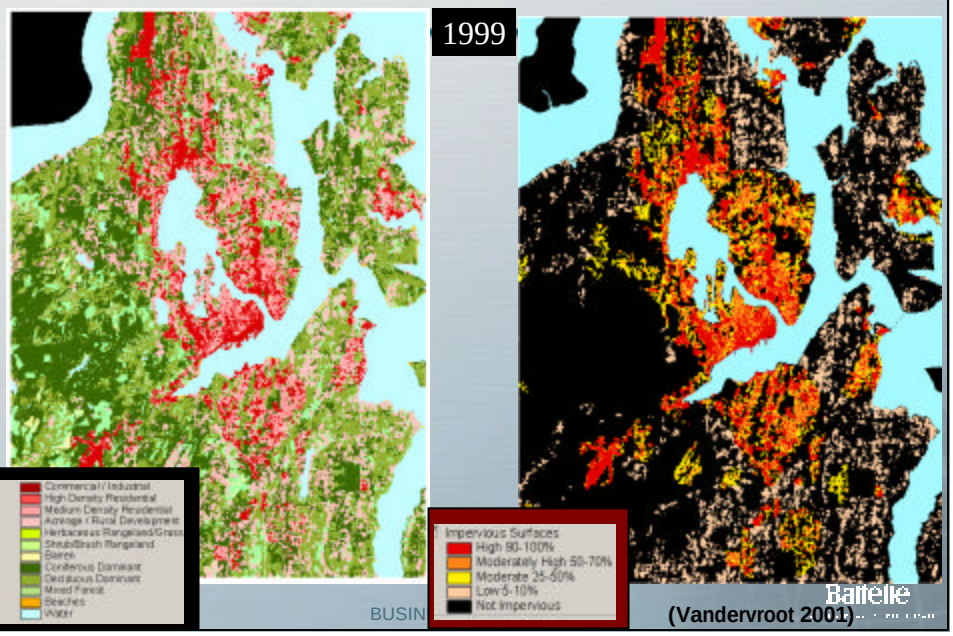





# Relationship with Storm Intensity



## Watershed Development




(Vandervroot 2001)



## First Cut: Correlations with LULC

| | Cu | Pb | Zn | Cd | Ag | As | Cr | Hg |
|---|---|---|---|---|---|---|---|---|
| Wooded | | | | | | W | | |
| Open Land | | | | | | | D | |
| Suburban | | | W | | | | | |
| Urban | W/D | D | D | D | | | | D |
| Streets/Hwy/Parking | | D | D | | W | | | |
| Transportation | | | | | | | | |
| Commercial | D | D | | D | W/D | | | D |
| Industrial | W/S | W | S | | W/S | | | S |
| % TIA | W/S | W/S | S | | W/S | | | S |

W = Wet Season (October thru April)

D = Dry Season (May thru September)

S = Qualifying Storm Events

## Conclusions

- First Flush concentrations are positively correlated with event mean concentrations (EMC) for both streams and storm drains. However, it may underestimate stream EMC.
- There is a relationship between EMC and storm intensity for streams. EMC for storm drains show a stronger relationship with land-use/land-cover (LULC).
- Positive correlations between %TIA and wet season/storm loading.
- Incorporate 2005 storm data and conduct regressions using storm intensity and LULC.





Project ENVVEST Technical Working Group Clambake featuring manila clams harvested from Dyes Inlet provided courtesy of the Suquamish Tribe.